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Introduction

The UK is the first, and so far only, country to pass *explicit legislation* allowing for the licensed use of a new reproductive technology: mitochondrial replacement techniques (MRTs) (The Human Fertilisation and Embryology (Mitochondrial Donation) Regulations 2015). These techniques may potentially prevent the transmission of mitochondrial DNA diseases. They are controversial because they involve the manipulation of oocytes, or embryos, and the transfer of genetic material. Some commentators have even suggested that MRTs constitute germline genome modification, a prospect which has long been the subject of ethical concern (González-Santos 2017).

While the ethical issues raised by MRTs continue to provoke academic debate, the UK has already granted the first license, of a two-step scheme, to Newcastle Fertility Centre; a second license now needs to be granted to a specific patient, which is yet to happen (Human Fertilisation and Embryology Authority 2017). Although the 2016 US Institute of Medicine's report on the ethical aspects of MRTs asserted that they are ethically permissible albeit limited to male embryos to avoid germline transmission, the FDA has been barred from even acknowledging the receipt of applications to carry them out (Adashi and Cohen 2017). It appears that this situation will not change under the Trump administration.

Given these antecedents, all eyes were on the UK as the most likely location for the first MRT birth, so it was a shock to the scientific community and the world at large when, on 27 September 2016, it was announced that the first MRT baby had already been born (Hamzelou 2016). US-based scientist Dr John Zhang used maternal spindle transfer (one of the recognised methods of MRTs, see Craven et al. (2017)) to generate five embryos for a woman carrying oocytes with deleterious mutations of the mitochondrial DNA in New York City. Zhang then shipped the only euploid embryo to Mexico, where it was transferred to the mother's uterus. The baby was born in April 2016 and is apparently doing well.

While this is a happy result for the new family, the consequences of Zhang's actions, crossing borders to achieve an early first in this field, will continue to be felt and have implications for: i) health research in Mexico, ii) the reproductive rights of Mexicans, and iii) the global politics of science. Medical tourism, in which patients travel

outside the country where they reside in order to seek medical care, has received much ethical attention; Zhang's actions, travelling outside his country to carry out experimental procedures, represent a form of 'scientific tourism' which has not been properly ethically explored. In this commentary we suggest, taking Mexico as an example, that this particular mode of scientific tourism can have seriously detrimental effects for developing countries. An awareness of the consequences of these events in the global context is essential as we continue to contemplate policy in this 'controversial' area.

Local Adverse Effects

The first and most immediate concern is the potential for *local adverse effects* on reproductive health and the regulation of research. In Mexico, a country with a strong conservative presence, embryo research and reproductive health are highly contested areas. For example, the political influence of the Catholic Church, and the extensive lobbying and protests led by conservative organisations such as the National Family Front, have had a significant impact on legislators in this area. Since 2007, several state constitutions around the country have been changed to protect human life from the moment of conception (i.e. implantation) or fertilization (Altamirano 2016; Beauregard 2016, 2017).

Access to reproductive health technologies and scientific research in this area are thus already in a precarious position. In light of current moves to revise and clarify the federal laws governing assisted reproduction, and the use of human embryos, the revelation of Zhang's work may have especially damaging effects (Reardon 2016). The negative publicity directed at this event on the international stage and the associated vilification of Mexico as a country with lax regulation provides ammunition to conservative groups who are seeking to make the law more restrictive (Palacios-González 2016).

Further, an absence of explicit regulation does not necessarily mean "anything goes" or that there is no will to regulate. In some cases, a deliberate legal lacuna can itself be a form of regulatory compromise *pro tem* (Luna and Salles 2010); in others, such as in Mexico, regulation is a *debate in progress*, moving forward as the result of complex negotiation between competing positions with high political capital. Short-

circuiting this process by taking advantage of interim uncertainties threatens to disrupt this delicate balance and foster a regulatory backlash.

It might be argued that scientific tourism can have beneficial effects for local science, if training and technology transfer contribute to local capacity-building. In this case, however, given that Zhang's team only intends to transfer the embryos in Mexico while carrying out the MRT procedures in the US, this seems unlikely. Zhang recently stated that: "For now, our nuclear transfer technique is very much like an iPhone that's designed in California and assembled in China" (Mullin 2017). This does not indicate much intention to promote development of Mexican science.

Consequences for the Long-Term Development of Science

Beyond these immediate consequences, scientific tourism can have wider implications for the long-term development of science in under-resourced destination countries. If regulation becomes more restrictive as a result of scientific tourism, local scientists will be unable to pursue their research in their home country. Given that scientists in these countries often lack sufficient resources to engage in scientific tourism themselves, the net effect will be to block or substantively delay their work altogether, as has happened to the first Mexican scientist to derive an embryonic stem-cell line in Mexico (Reardon 2016). The adverse impact of this could be thus threefold. First, it contributes to the brain drain of developing countries, with associated adverse effects in local scientific communities and health resources. Second, it further disadvantages scientists in countries where research already lacks support, or is hampered by unclear regulation. Third, it affects a country's overall scientific competitiveness in the long term. This, obviously, creates a clear problem of global scientific justice.

The response to Zhang's work also reflects a deeper problem of what we might call 'scientific chauvinism', whereby criteria for scientific practice, regulatory standards and the terms of public discourse over science are dictated by the dominant scientific community. Deviations, which often fall out along cultural and political boundaries, are automatically classified as unscientific, unethical or unacceptable (Sipp and Pei 2016). However, in the case of Mexico it is not a matter of different *ethical* standards: the moral sensitivity of this area of research and the need for regulation and oversight

is recognised in Mexico, even if the response to that need has so far been less than effective. Advisory groups in both the UK and US, and much of the bioethics literature, have deemed the technique to be ethically acceptable, at least in principle. Zhang's move to Mexico for the embryo transfer process was therefore more a matter of escaping local oversight than going against ethical prescriptions. Should blame for this be attributed solely to the inadequacy of Mexican regulation?

We suggest that this mode of allocating responsibility for scientists' conduct reveals a problem in attitudes to global science and governance. When ethical questions arise about research in more developed countries, the assumption is generally that the scientist must have done something wrong, while the regulatory system and scientific culture is only a *secondary* object of scrutiny. The mainstream coverage of the ethical problems that emerged in relation to Paolo Macchiarini's work on tissue-engineering transplants, for example, focused principally on his character and actions and the individual roles of others who enabled his actions, rather than on Sweden's scientific culture and its regulatory and governance systems (Abbott 2016).

When controversial or ethically dubious work is revealed in countries such as Mexico, on the other hand, the first assumption is often that there is something wrong with the system, be it insufficient regulation, inadequate oversight or inappropriate ethical standards. Most commentators took on face value Zhang's statement that in Mexico "there are no rules" (Hamzelou 2016). In fact, Mexico does have rules regarding both research oversight and assisted reproduction; indeed, it is possible that Zhang's team violated federal regulations on medical research(Palacios-González and Medina-Arellano 2017; Ishii 2017). Focusing solely on Mexico's apparent failure to conform to the standards of ethics and regulation upheld in supposedly more developed countries deflects attention from the responsibilities of scientists and reinforces biased attitudes about global ethical standards and the governance of science. We may draw a comparison here with gene editing and the ethical scepticism expressed towards the Chinese studies published on embryo gene editing. Such attitudes reflect the perception of a 'Wild East' with inferior ethical standards and inadequate regulation, an assumption that is not necessarily justified (Sipp and Pei 2016).

Finally, the MRTs situation also illustrates a problem of justice with respect to regulatory capacity. Scientific tourism can impose an unfair oversight burden on countries where ethics and governance structures for these technologies are under development. Researchers who travel to take advantage of an already overloaded system are unjustifiably increasing the burden of local oversight in order to further their own academic and otherwise interests. If we consider that the scientific 'brain drain' (of human resources) or 'biopiracy' (of genetic or biological resources) are problems for global scientific justice, then siphoning off oversight resources by engaging in scientific tourism ought equally to be regarded as problematic.

There is, though, one possible positive outcome of this event for Mexico. Spurred by worldwide attention to Zhang's work, a national debate on assisted reproduction that includes scientists, stakeholders and bioethicists might ensue, leading to an adequate regulatory framework that does not stifle scientific advancement. This possibility is remote at present due to Mexico's political climate, but it is one that we must try to promote.

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